

Variable Vector Countermeasure Suit for Space Habitation and Exploration (V2Suit)

Completed Technology Project (2011 - 2012)



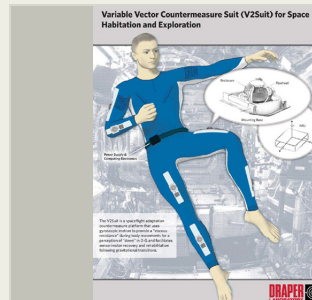
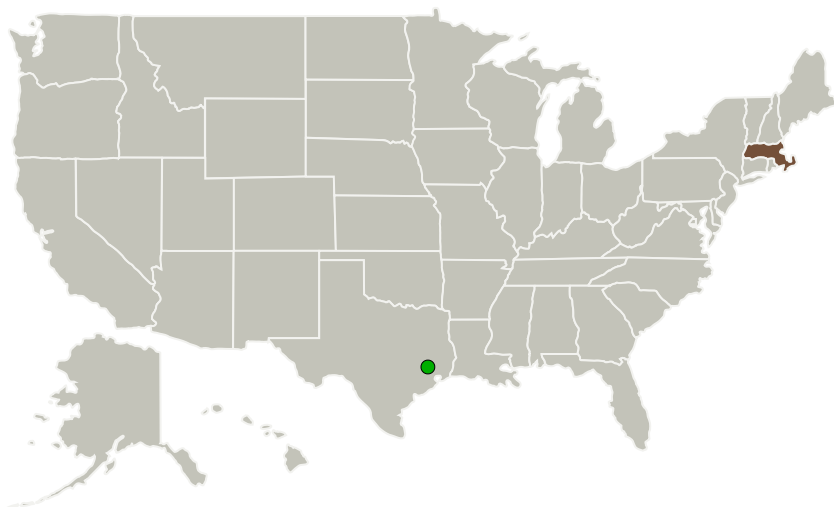
Project Introduction

The Variable Vector Countermeasure Suit (V2Suit) is a specialized spacesuit designed to keep astronauts healthy during long-duration space exploration missions and help stabilize them while they work in microgravity. The initial V2Suit prototype will integrate gyroscopes and accelerometers to track the position and orientation of body segments and use flywheels to provide a "viscous resistance" during movements to replicate the sensation of gravity during movements in 0-G.

Anticipated Benefits

The successful development and integration of the V2Suit will be a be an enabler for several proposed space exploration mission technologies, including human health and adaptation countermeasures, autonomous health monitoring, human robotic interfaces, and adaptation and operations during artificial gravity. It will initially fill a void in the spaceflight health and performance countermeasures program, by enabling a training curriculum and countermeasures for sensorimotor adaptation. This type of countermeasure suit also has hearth benefits, particularly in gait or movement stabilization for the elderly, or rehabilitating individuals. In addition, with knowledge of the environment and the planned task, the system could be commanded to enforce "keep out zones" -- spatial regions that if penetrated with a body limb could cause harm to either the person or the equipment.

Primary U.S. Work Locations and Key Partners



Project Image Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration

Table of Contents

Project Introduction	1
Anticipated Benefits	1
Primary U.S. Work Locations and Key Partners	1
Project Transitions	2
Organizational Responsibility	2
Project Management	2
Technology Maturity (TRL)	2
Technology Areas	3
Target Destinations	3
Images	4
Links	4

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Organizations Performing Work	Role	Type	Location
The Charles Stark Draper Laboratory, Inc.	Lead Organization	R&D Center	Cambridge, Massachusetts
● Johnson Space Center(JSC)	Supporting Organization	NASA Center	Houston, Texas

Primary U.S. Work Locations

Massachusetts

Project Transitions

**September 2011:** Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

The Charles Stark Draper Laboratory, Inc.

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

Eric A Eberly

Principal Investigator:

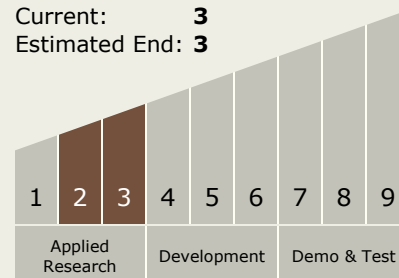
Kevin W Duda

Technology Maturity (TRL)

Start: 2

Current: 3

Estimated End: 3



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September 2012: Closed out

Closeout Summary: The Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration is a visionary system concept that will revolutionize space missions by providing a platform for integrating sensors and actuators with daily astronaut intravehicular activities to improve human health and performance. The V2Suit uses control moment gyroscopes (CMGs) within a miniaturized module placed on body segments to provide a viscous resistance during movements - a countermeasure to the sensorimotor and musculoskeletal adaptation performance decrements that manifest themselves while living and working in microgravity and during gravitational transitions during long-duration spaceflight, including post-flight recovery and rehabilitation. Through an integrated design, system initialization, and control systems approach the V2Suit is capable of generating this viscous resistance along an arbitrarily specified direction of down. When movements are made, for example, parallel to that down direction a resistance is applied, and when the movement is perpendicular to that direction no resistance is applied. The V2Suit proposes to be a countermeasure to this spaceflight-related adaptation and de-conditioning and the unique sensorimotor characteristics associated with living and working in 0-G, which are critical for future long-duration space missions. This NIAC Phase I project focused on detailing several aspects of the V2Suit concept, including human-system integration, system architecture, computer aided design (CAD) modeling, and closed-loop simulation and analysis. In addition, early-stage breadboard prototyping of several aspects of the V2Suit system modules enabled characterization of expected performance and identified areas for further research and development to enable operational implementation of the V2Suit. In particular, potential challenges with integration of commercial-off-the-shelf components were identified. The key enabler for operational use and adoption of the V2Suit is a low-profile body worn form factor that does not interfere with normal, everyday movements and interfaces adequately with the body as to provide the generated gyroscopic torque for the perceptions of movement with a viscous resistance. These aspects were investigated through mockups using a life-size mannequin, and through body attachment mechanisms on the breadboard prototype. Through the evaluation and investigation of commercially-available components, as well as an identification of desirable form factors, CAD models of the V2Suit modules were developed. These models included all of the required elements - spin motors, flywheel masses, gimbal motors, slip rings, inertial measurement units, motor controllers, and the required mounting brackets/hardware and cabling. The configuration and orientation of the control moment gyroscopes (CMGs) was specified according to results from the modeling, simulation and analysis. Two revisions of the CAD model were investigated through closed-loop simulation of the CMGs, and their ability to generate a resultant reaction force during movement and null undesirable torques due to changes in the direction of the angular momentum vector as a result of the normal body movements. The simulation architecture was based on the V2Suit system architecture, including the ability to initialize the system, track the position, orientation, and movement of the modules, and command the CMGs to provide the required direction and magnitude of the gyroscopic torque. These simulations demonstrated that the feasibility of the concept, and validated aspects of the design, including the CMG orientation and that the spin and gimbal rates required can be provided using commercially available components. Finally, a breadboard prototype was developed, which included several aspects of the V2Suit system. Custom flywheels were integrated with commercially available motors, a three axis accelerometer, and motor controllers - all packaged into a body-worn form factor. Data from the accelerometer could be read, and motor speed commands sent to

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
 - └ TX06.2 Extravehicular Activity Systems
 - └ TX06.2.4 Decompression Sickness Mitigation

Target Destinations

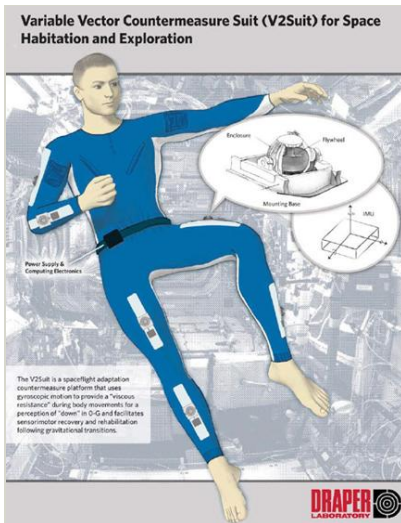
Earth, The Moon, Mars

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Images



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Project Image Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration (<https://techport.nasa.gov/image/102236>)

Links

Patent Link 1
(no url provided)